Runway Incursion Prevention System Research

Denise R. Jones

National Aeronautics and Space Administration
Langley Research Center
Hampton, VA

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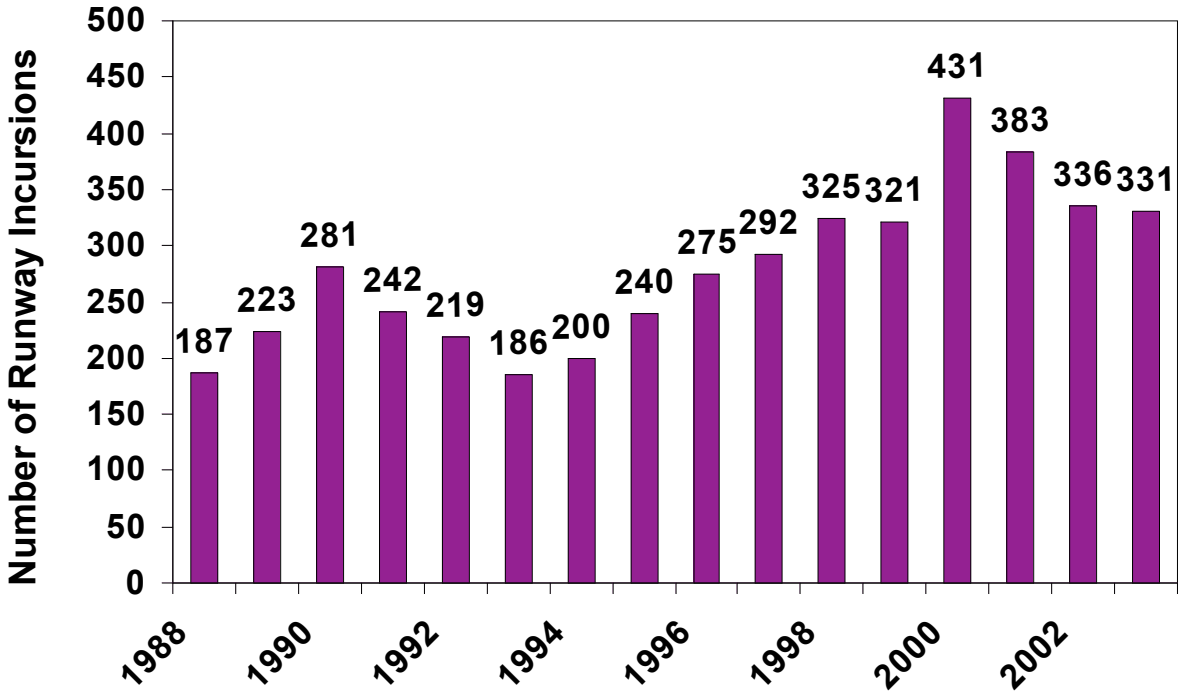
denise.r.jones@nasa.gov

Runway Incursion Background

Runway Incursion Definition

"Any occurrence in the airport runway environment involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in a loss of required separation with an aircraft taking off, intending to take off, landing, or intending to land."

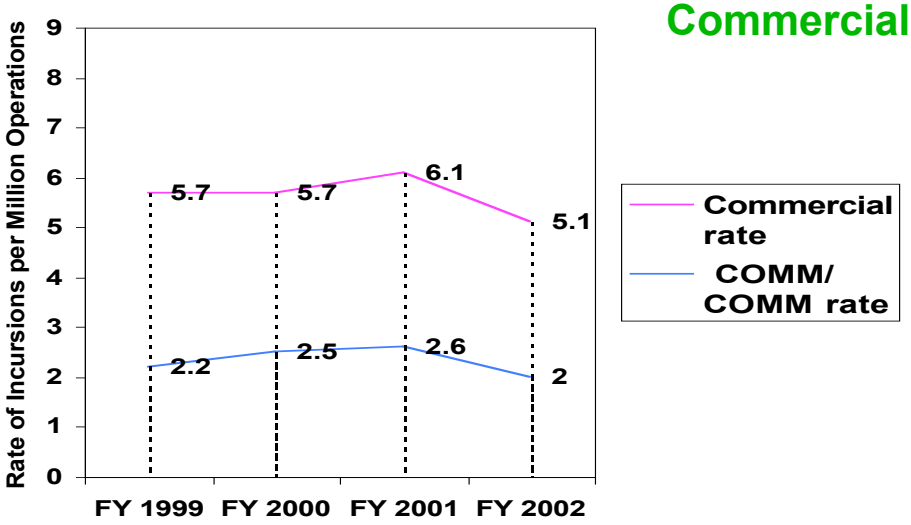
- FAA Runway Safety Report, July 2003



Source: FAA Runway Safety Program

Runway Incursion Rates

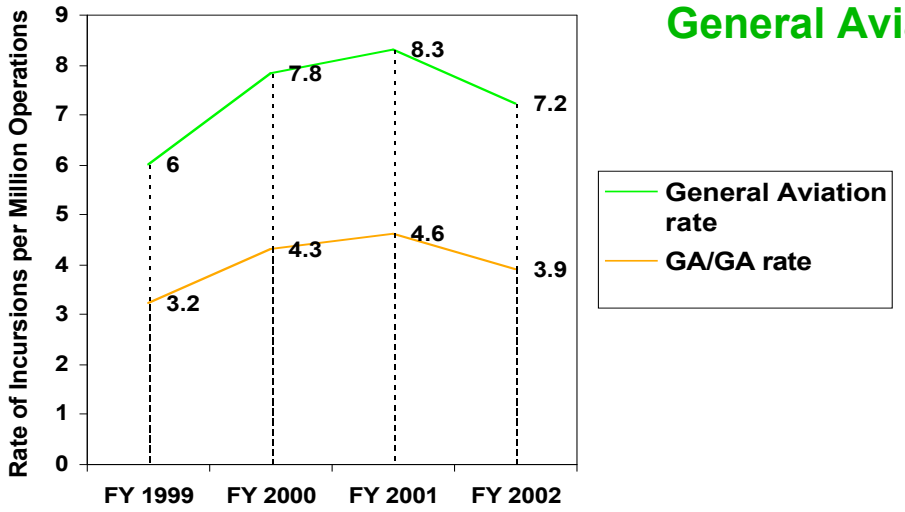
Aviation Safety Program - Runway Incursion Prevention Systems



Commercial Aviation Operations

From FY 1999 through FY 2002-
- 38% of all aircraft operations
- 573 (39%) incursions involved at least one commercial operation

For FY 2002-
- One event every 2.9 days with at least one commercial operation
- One COMM/COMM incursion every 7.5 days



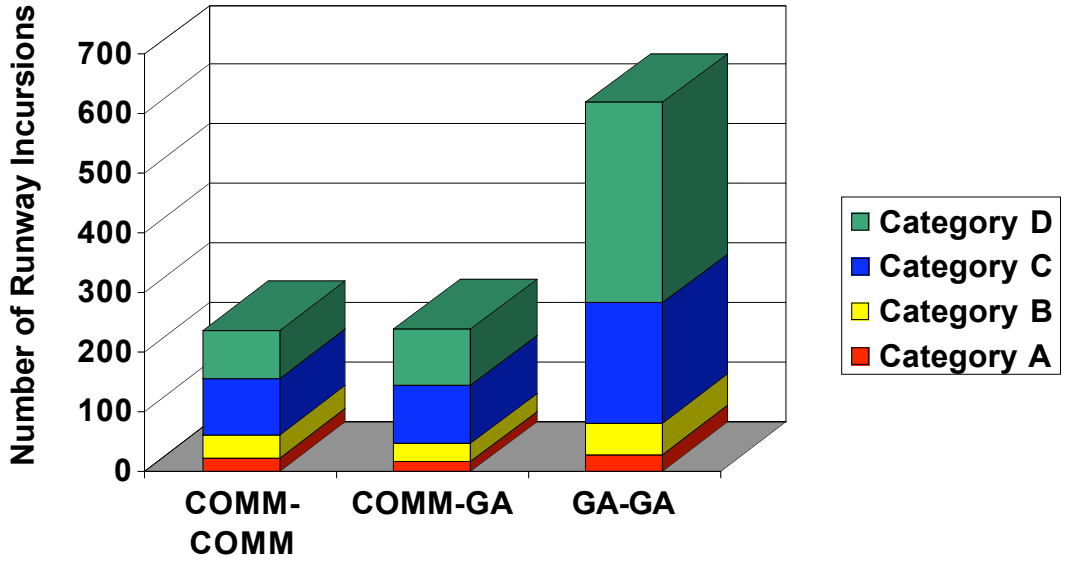
General Aviation Operations

From FY 1999 through FY 2002-
- 58% of all aircraft operations
- 1131 (76%) incursions involved at least one general aviation operation

For FY 2002 –
- One event every 1.4 days with at least one general aviation operation
- One GA/GA incursion every 2.5 days

Runway Incursions by Severity Category

FY 1999 - FY 2002



Category D	Category C	Category B	Category A
Little or no chance of collision but meets the definition of a runway incursion	Separation decreases but there is ample time and distance to avoid a potential collision	Separation decreases and there is a significant potential for collision	Separation decreases and participants take extreme action to narrowly avoid a collision, or the event results in a collision

Increasing Severity

* *FAA Runway Safety Report, July 2003*

RIPS: A System Solution

The Runway Incursion Prevention System (RIPS) is designed to prevent runway incursions in any visibility condition through technologies that enhance surface situational awareness, navigation, and alerting for the pilot.

Runway Incursion Avoidance

Ability to reduce the likelihood of inadvertent entry onto an active runway.

- Own-ship position awareness
- Traffic position awareness
- Route awareness
- Route deviation detection

Runway Incursion Detection

Ability to become aware that an incursion has occurred so that corrective action can be taken, if necessary, to avoid conflict.

- Timely alerting to flight crew and ATC

Runway Incursion Prevention System

Multi-staged Airborne Incursion Prevention Strategy

Aviation Safety Program - Runway Incursion Prevention Systems

II. Know where others are

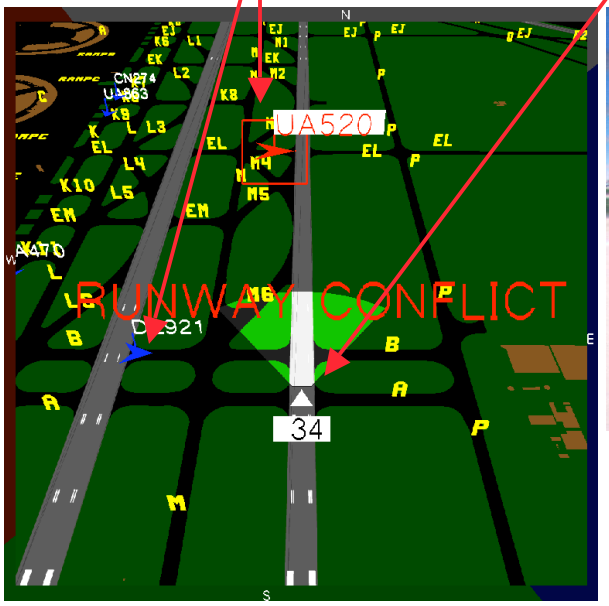
Traffic position awareness
(ADS-B or TIS-B data link)

I. Know where you are

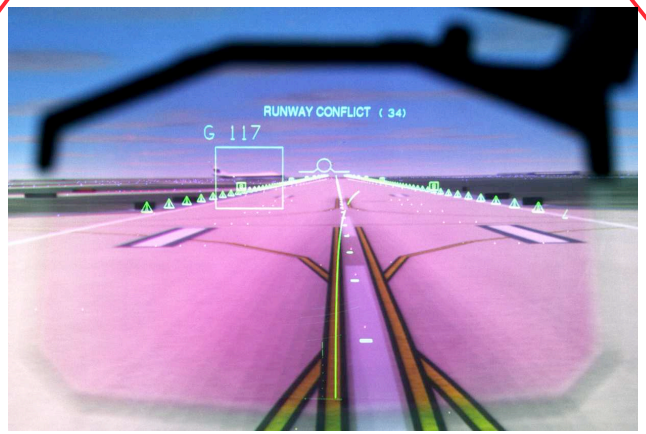
Own-ship position awareness
(GPS & airport database)

III. Know where to go

Route awareness
(Taxi route from ATC)



Departure Surface Map



HUD Guidance

"Runway Conflict"
"Runway Traffic"
"Crossing Hold"
"Off Route"

Taxi Surface Map

IV. Know when a mistake occurs

Incursion detection
(Immediately alert flight crew & ATC)

System Testing

Runway Incursion Avoidance (1993 – 1998)

- Simulation studies (LaRC and ARC)
- 1995, B-737 flight testing at FAA Technical Center, Atlantic City, NJ
- 1997, B-757 flight testing at Hartsfield Atlanta International Airport

System concept installed in Flight Simulation Facility (ATC interface not shown)

System Testing

Runway Incursion Detection (1999 – present)

2000, B-757 flight testing at Dallas-Ft. Worth International Airport

- RIPS integrated with FAA's surveillance system
- Aircraft based detection algorithms
- Surface based alert detection
  (transmitted to aircraft)
- 47 test runs, 4 airline captains as subjects

Results:

- Aircraft based detection provided more timely alerting for the flight crew than transmitting the surface generated alerts to the aircraft.
- Reliable, accurate, and timely traffic and own-ship data is required for effective onboard incursion detection alerting.
- The flight testing demonstrated the feasibility of providing aircraft based runway incursion detection.

- Pilots felt more safe with RIPS onboard!

System Testing

Runway Incursion Detection (1999 – present)

2002, Full mission simulation study

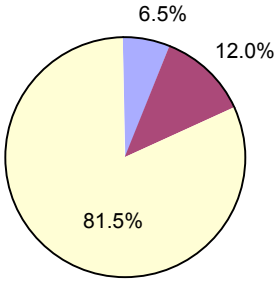
- RIPS algorithm and display enhancements based on flight testing results
- Evaluate alerting timeliness, alert type (caution and warning), display concept, display configuration (complete RIPS vs surface map only vs baseline)
- 467 test runs, 5 scenarios, 8 flight crews as subjects

Results:

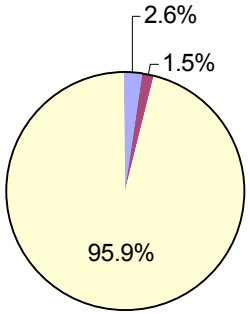
- On approach, alerting provided greater safety margins over surface map alone in low visibility
- On departure, RTO conducted sooner with alerting, particularly in low visibility
- Surface map effective in preventing incursions when own-ship crossing runway, as long as traffic visible on map
- Airport overview mode effective in providing early awareness of runway traffic on approach
- More advance warning needed when in position and hold

Monte Carlo Results

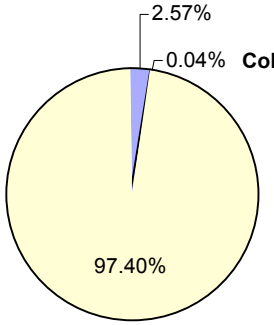
Taxi Crossing / Arrival



No Evasive Maneuver



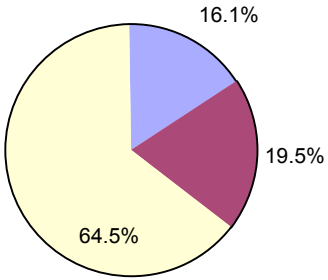
Evasive Maneuver Ownship Only



Evasive Maneuver Both A/C

Near Collisions
Collisions
Safe Separation

Taxi Crossing / Departure



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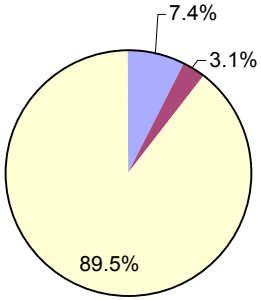
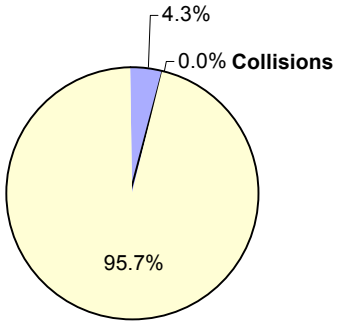


Evasive Maneuver Ownship Only



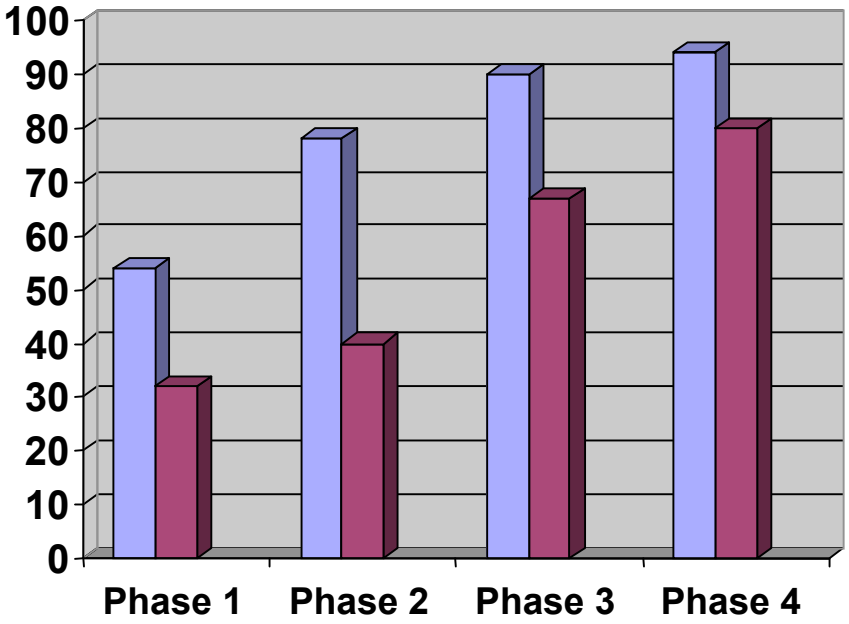
Evasive Maneuver Both A/C

*[Rannoch Corp., 2002], "Development of the Runway Incursion Advisory and Alerting System (RIAAS)"

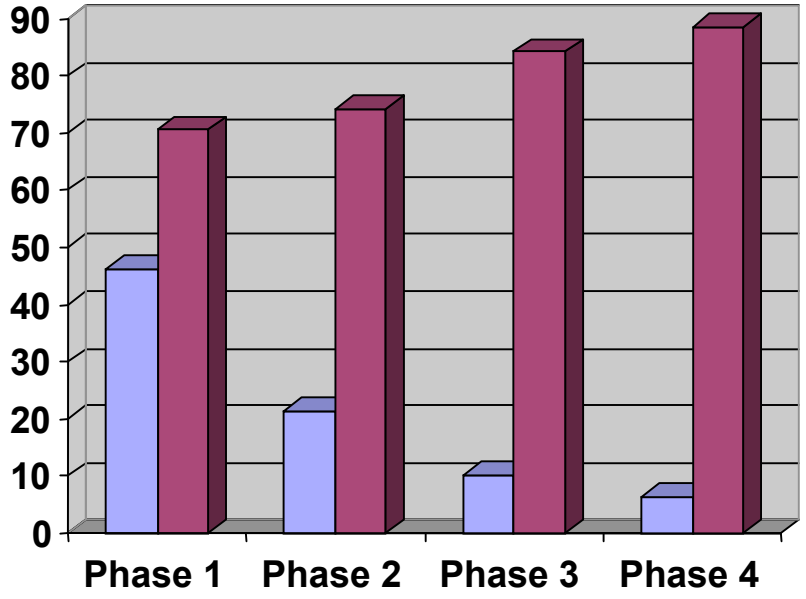
Potential Safety Improvement

Aviation Safety Program - Runway Incursion Prevention Systems

Incidents Prevented



Incidents Not Prevented



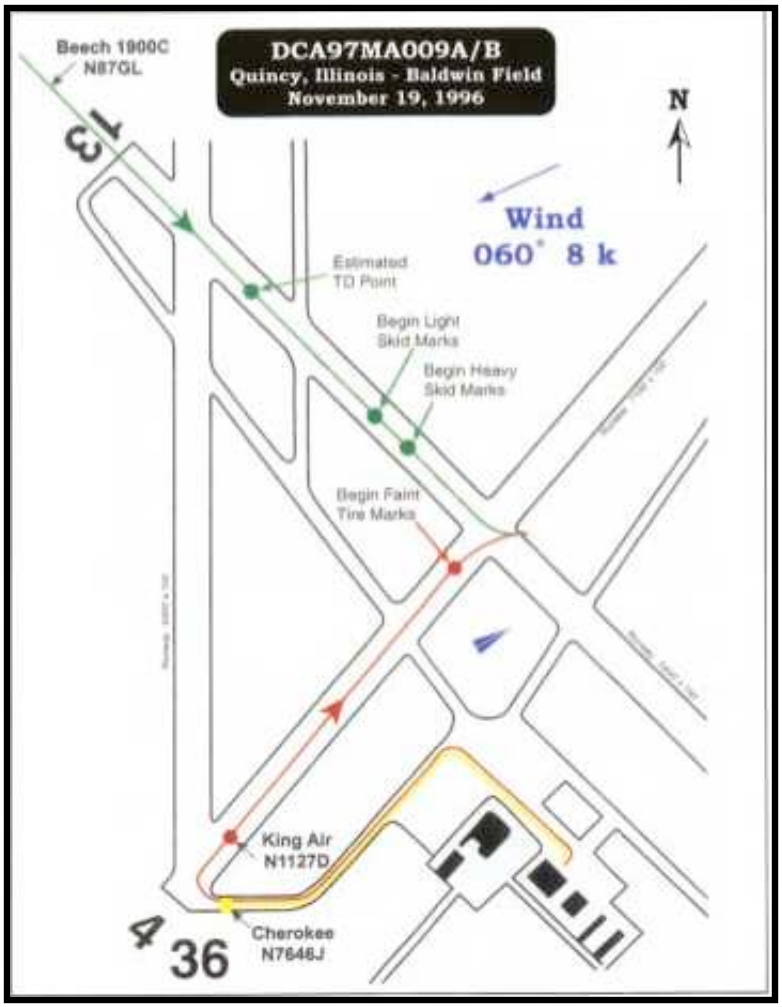
Phase 1: Surface Map + Ownship
Phase 2: Phase 1 + Traffic
Phase 3: Phase 2 + Alerting
Phase 4: Phase 3 + Route

% Prevented
Av. Confidence (x10)

N = 223 (Aviation Safety Reporting System)

[Boucek, 2002], "Surface Accident and Incident Taxonomy and Mitigation Strategies"

Runway Incursion Accident



Quincy, IL, November 19, 1996
5:01 pm, VMC
14 Fatalities
Uncontrolled airport

1 – Beech 1900C commuter landing on runway 13 while Beech King Air A90 taking off on runway 4.

2 – Point of collision: runway intersection

3 – Probable cause: failure of King Air pilots to effectively monitor common traffic advisory frequency or properly scan for traffic

Using RIPS, this accident may have been avoided:

Beech 1900C -Display of traffic on runway 4
-Detection and alert of runway incursion

King Air -Display of traffic on runway 13
-Detection and alert of runway incursion

RIPS GA Research Areas

What modifications must be made to the alerting logic and thresholds for the incursion detection algorithms for GA operations?

Aircraft Characteristics

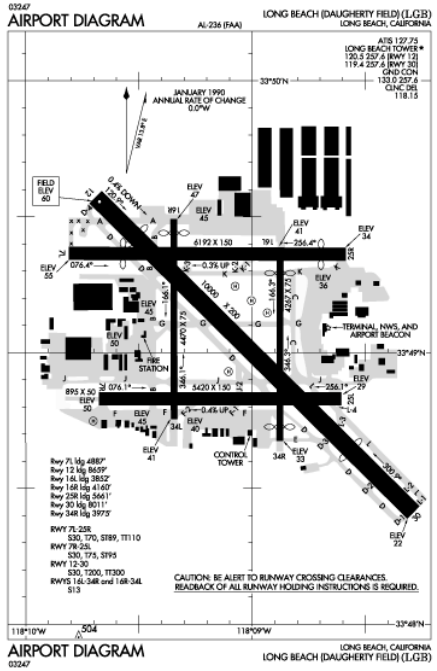
- Size
- Maneuverability
- Approach and takeoff speeds
- Acceleration and deceleration rates
- Climb and Decent rates

Position Data

- Un-augmented GPS
- WAAS

GA Operations and Airports

- Reduced separations
- Airport geometry
  - Runway spacing
  - Hold line locations



GA Airport Database

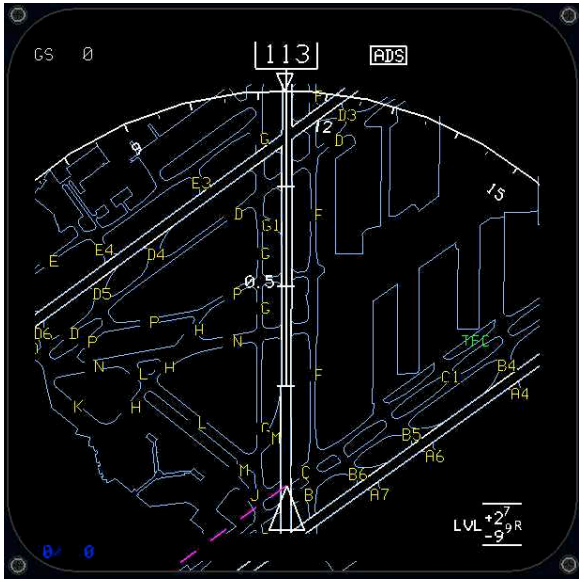
- Availability
- Accuracy
- Completeness

RIPS GA Research Areas

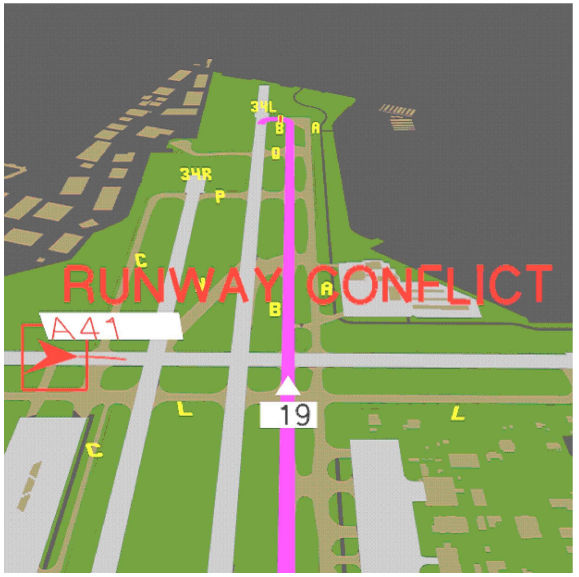
What is the most effective method of presenting surface situational awareness and runway conflict alerts to pilots of low and high end GA aircraft?

"Runway Conflict"
"Runway Conflict Ahead"
"Runway Traffic"
"Traffic on Approach"
"Crossing Hold"
"Off Route"

Audible Alerts

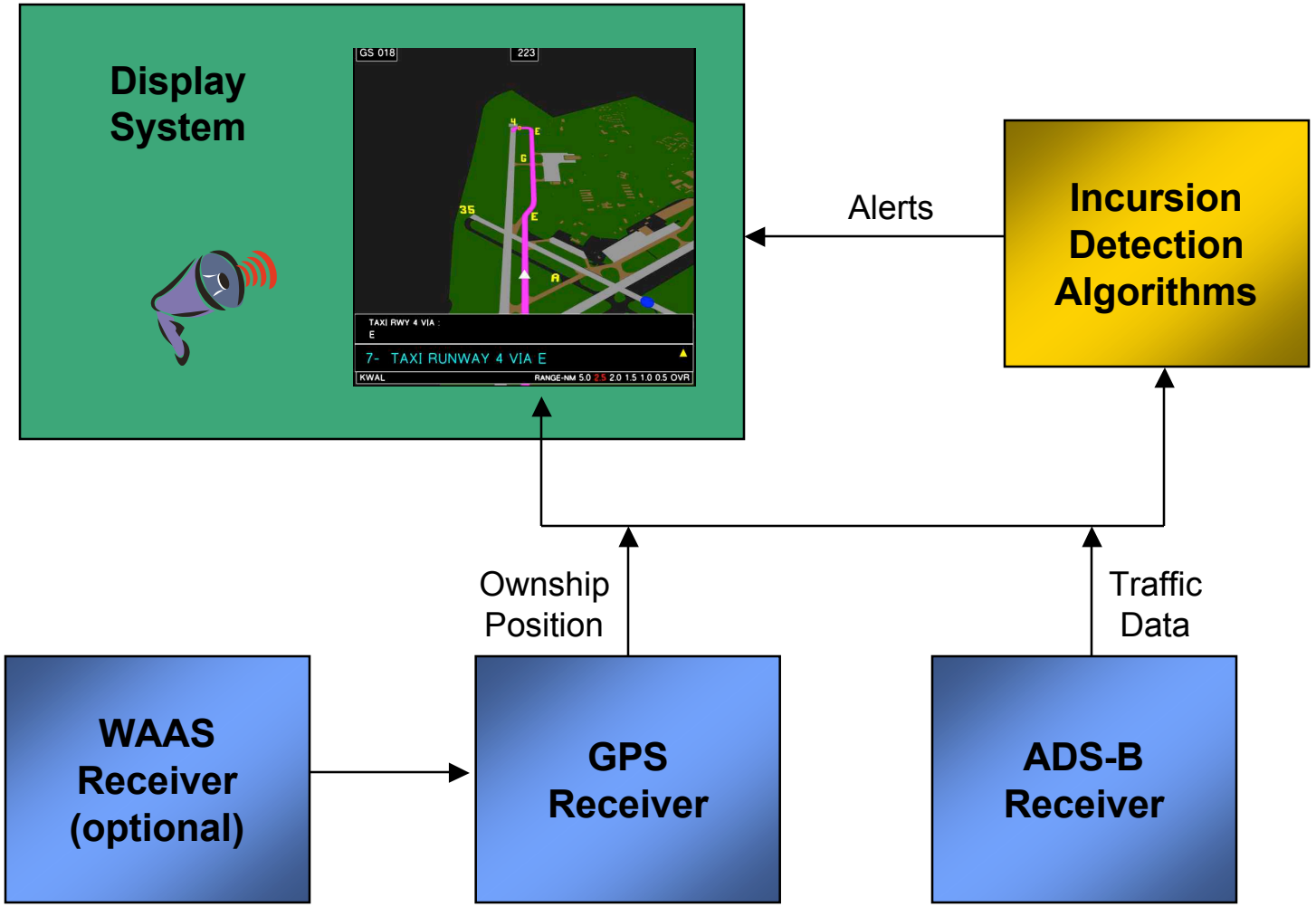


Basic Surface Map



Advanced Surface Map

Potential Airborne Architecture



RIPS GA Testing

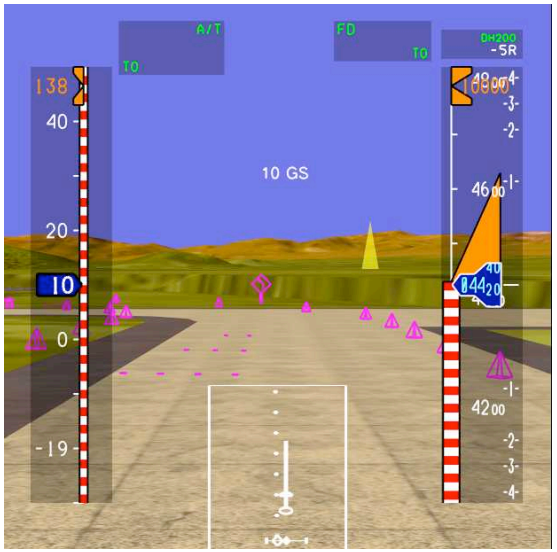
Test scenarios –

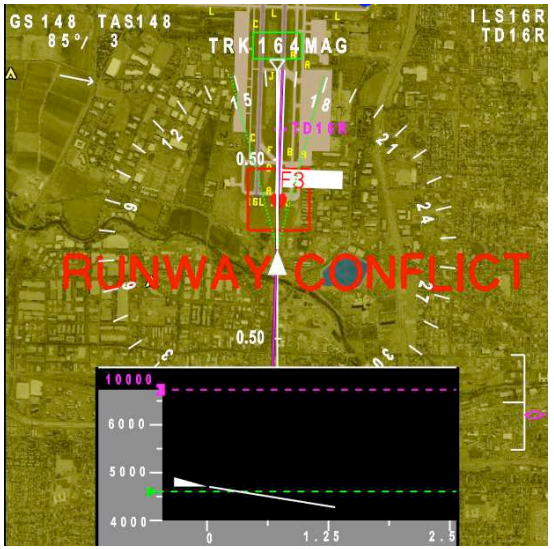
- Arrival/departure and taxi crossing
- Arrival/departure on same runway
- Crossing runways
- Reduced separation scenarios

Simulation – General Aviation Work Station (GAWS)

Flight testing – GA airport and mixed fleet airport

What's Next





- RIPS - SVS integrated flight testing planned for 2004 at Reno and Wallops Flight Facility
  - Crossing runway incursion scenarios
- Integrated simulation planned for 2004
  - SVS integrated with RIPS, rare event incursion testing
- RIPS adapted for general aviation operations
  - Rannoch Phase II SBIR